NOAA Special Report

SUPERSTRUCTURE ICING IN ALASKAN WATERS

J.L. WISE
A.L. COMISKEY

Pacific Marine Environmental Laboratory
Seattle, Washington

April 1980

U.S. DEPARTMENT OF COMMERCE
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FOREWORD

Superstructure icing conditions are quite common in Alaskan waters, and extreme conditions have resulted in loss of lives and vessels. This study draws together a new body of marine icing observations and is intended to stimulate interest in the physics of the marine structural icing problem. The research on superstructure icing has been monitored and funded by the Marine Meteorological Studies Group at Pacific Marine Environmental Laboratory (PMEL)and was carried out by J. L. Wise and A. L. Comiskey of the Arctic Environmental Information and Data Center of the University of Alaska (AEIDC). This work is in keeping with PMEL's Marine Services Project mission to conduct research in marine weather and ocean forecasting and to transfer the information to operational forecasting units in the National Weather Service and to other interested users.

Carol H. Pease
Oceanographer
Marine Meteorological Studies Group
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SUPERSTRUCTURE ICING IN ALASKAN WATERS*

J. L. Wise and A. L Comiskey**

ABSTRACT. This study addresses the acquisition of marine structure icing data, integration and correlation of the factors that affect icing accumulation rates, and application of the correlations so that the mariner or forecaster can accurately predict icing accumulation rates. Nomograms applicable to the Northeast Pacific were developed to predict icing accumulation rates. A map depicting probable areas of most frequent and most heavy icing is also presented.

1. INTRODUCTION

Passage of the Fishery Conservation and Management Act of 1976, followed by management decisions favoring U.S. fishermen, economic changes, the search for and production of fossil fuels, and other factors have caused rapid acceleration of winter marine activity. Five years ago, for example, only a handful of U.S. ships plied the waters of the Bering Sea. Now there may be as many as 200, even during the most severe winter weather conditions. During this period in Alaska, winters were unusually mild until that of 1979-80, which was probably an average icing winter. Many boat operators were new to Alaskan waters or had never before fished in winter and were unfamiliar with superstructure icing. Because of fear for their safety and the need for additional knowledge of the phenomenon, this study was undertaken in the early winter of 1979-80. Coincidentally, a number of ships experienced serious icing problems that winter. For example, on January 14, a 110-ft (34 m) crabber, "The Gemini," iced up and capsized. Two crew members were lost, and three were miraculously rescued after more than four days in a raft during conditions of extreme cold and high seas.

2. DEFINITIONS

Marine Structures: Ships, boats, stationary drill ships, semisubmersible drill rigs, or anything that is surrounded by or in proximity of the ocean.

Structure Icing: Icing on either land-based or marine structures.

Superstructure Icing: Icing caused by sea spray on marine structures.

Atmospheric Icing: Icing of any structure caused by atmospheric phenomena, such as freezing rain, ice fog, etc. Rarely serious on marine structures but can be a problem on land-based radar towers, antennas, etc.

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*Contribution No. 468 from the NOAA/ERL Pacific Marine Environmental Laboratory.

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Sea Ice: Ice on the ocean's surface. This occurs when water temperature cools below its freezing point, about 29° F (-1.7°C) for salt water.

Ice Accumulation: The amount of ice, measured either by depth or weight, that a marine structure has accumulated at a specific point in time; e.g., "We had accumulated 5 inches (12.5 cm) when I got off shift."

Ice Accumulation Rate: The rate of ice accumulation, measured either by depth or weight, during a specific time interval; e.g., "We got 3 inches (7.5 cm) of ice between midnight and 4 a.m."

3. DATA ACQUISITION

We found no evidence that any person or organization had ever attempted to compile superstructure icing data for the Northeast Pacific prior to this study. Considerable amounts of such data exist for the Northeast Atlantic (Mertins, 1968); lesser amounts have been acquired for the Northwest Atlantic (Stallabrass, 1979). We assume that there are data for the seas of Japan and Ikhotsk and areas along the southeast coast of the Kamchatka Peninsula and the Siberian Bering Sea coast, but we did not investigate these or other geographically oriented material as part of this study.

The first phase of the project was to establish contact with sources of needed data. Real-time data was acquired from ship reports collected by radio and relayed by phone and U.S. government-leased teletype circuits. The principal individual contact for real-time data was Peggy Dyson, a Kodiak-based radio operator who collects informal, high-quality ship reports from ship operators in the Gulf of Alaska and the Bering Sea. The reports were relayed twice daily to the National Weather Service (NWS) office in Kodiak, where they were entered into the teletype system and transmitted to the NSW Forecast Office in Anchorage. AEIDC collected these reports daily during icing episodes. A total of 51 real-time reports were received, 13 of which were from the "Ocean Bounty" a semi-submersible drilling platform located at 59°12'N 152°32'W, under contract to Phillips Petroleum Co. The "Ocean Bounty" also provided 25 additional near-real-time data reports. Ocean Routes, a meteorological service company also under contract to Phillips, reported icing incidents to Peggy Dyson, and filled out additional icing report forms (see Appendix 1).

The primary sources of historical icing data are the ship's logs of the Alaska Ferry System and U.S. Coast Guard ships that have operated in Alaskan waters. Some very old ship's logs, archived by the University of Alaska, might be used later in a larger correlation study of icing and meteorological data. NOAA ship historical data were not included because the data base is maintained in Seattle and logistical limitations prevented their inclusion.

The next phase of data acquisition involved design and distribution of four separate icing documentation forms (see Appendix 1). One form was to be completed by ship personnel and mailed to AEIDC; another was for

use by the AEIDC interviewer in documenting a case using real-time reports and concurrent weather maps and weather data; another was for transferring historical data into a usable format; and the fourth was for recording information from stationary marine structures. Form No. 1 was distributed to harbor masters, aquatic marketing associations, seafood processors, the U.S. Coast Guard, the Alaska State Ferry System, Puget Sound Tug and Barge, Foss Launch and Tug, Alaska Marine Shipping, and private ship operators.

To optimize cooperation from the marine community we placed classified ads in the Kodiak Mirror and issued a description of the project to nonscientific groups (see Appendix 2). Extensive promotion was also accomplished by telephone.

Data were classified as quantified or nonquantified. Quantified data have specific ice accumulation rate information. A total of 49 quantified reports was received. Of these, 38 were only semiquantified, that is, icing rates were reported in terms of icing adjectives. For instance the adjective "moderate" encompasses a set with values between 1.5 in/24 hr (3.8 cm/24 hr) and 2.6 in/24 hr (6.6 cm/24 hr).

Nonquantified data have no specific rate or set of rates. These data were acquired from ship reports and ship logs. They were of no value for developing aids to forecast accumulation or accumulation rates, but they did help determine icing distribution and frequency. A map depicting areal distribution is discussed under DATA INTEGRATION AND ANALYSES RESULTS.

4. LITERATURE SEARCH

The U.S. Department of the Interior's Alaska Resources Library (ARL) conducted a computerized search of more than 100 data bases, but very few sources were discovered and those contained considerable redundancy. A paper by McLeod (1977), entitled Atmospheric Superstructure Ice Accumulation Measurements, dealt only with icing of land-based structures. Its value was to reaffirm our opinion that land-based structure icing is a different problem than marine icing. All other citations were either already known to us or did not coincide with the objective of this report. The lists of references in World Meteorological Organization Report No. 10 (Shellard, 1974), CRREL Report 77-17 (Minsk, 1977), and the National Research Council Canada (NRCA) LTR-LT-98 (Stallabrass, 1979) are much more complete and useful for marine icing studies than the search citations, even though the search citations included abstracts.

5. DATA INTEGRATION AND ANALYSES

There is a lack of present and past quantified data, which are critical to correlating icing rates with atmospheric-oceanic parameters. To attempt data integration and analysis with such a sparse data base could lead to misleading conclusions. But by using the semiquantified reports from the "Ocean Bounty," we found that we could plot a scattergram which correlates icing rate categories to air temperature and wave height

(Fig. 1). This correlation helped to substantiate and develop a nomogram for use aboard ship. The nomogram will be discussed later.

The oceanic and atmospheric dynamics of icing are identical for ships and fixed structures. However, the ship's mobility, aspect, and shape modify the effects of the oceanic and atmospheric dynamics in more ways than do the fixed structures. The fixed structure, on the other hand, has only the variable of shape. Because of this, the data from the fixed structures could be much more useful initially than the data from ships. However, the data from both sources are insufficient to allow comparison. The ship cases are few, and the method of observing ice thicknesses on fixed structures needs considerable refining. We tried to make the most of what we had from both sources.

In spite of the lack of quantified data, we believe we made some improvements to the nomogram now in use to forecast superstructure icing (Fig. 2) (Comiskey and Younker, 1976). Figure 2 is a second-order nomogram (SON) in that it was derived several years ago by integrating four nomograms by Mertins. Minor changes were subsequently made (Fig. 3). Note that the icing rates are expressed in 3-hr rather than 24-hr increments. Mertins' nomograms were used to derive Figures 2 and 3. Minor refinements made in the method used to transpose and integrate Mertins' nomograms into Figure 3 account for the slight differences between the figures.

We then studied the differences in climatology between the Northeast Atlantic, where we assume the Mertins data originated, and the Northeast Pacific. The most outstanding climatological difference was that the wet bulb temperature in the Northeast Pacific averages about 3°F (1.7°C) lower than the Northeast Atlantic during the coldest winter months (U.S. Navy, 1974 and 1977). In areas 6 (southeastern Bering), 7 (northwestern Gulf), and 8 (northeastern Gulf), (U. S. Navy Marine Climatic Atlas), nearly identical wet bulb/dry bulb spreads are indicated. In area 2 (central Bering) the spread is similar but the temperature is colder. The air off the ice is very similar to the air off the land. We theorized that the lower wet bulb temperatures in the Pacific equate to lower hull or superstructure temperatures and greater rates of icing. Subsequent correspondence with J. R. Stallabrass substantiated this. In the NRCC LTR-LT-98 (Stallabrass, 1979), Stallabrass had derived an equation for predicting the icing rates of fishing trawlers, but he assumed that the relative humidity in the icing area would be close to 100 percent, which is frequently not the case in the Northeast Pacific. In a later letter Mr. Stallabrass agreed with us, stating that the relative humidity may have an appreciable effect. He subsequently introduced a humidity term (vapor pressure) into the equation and computed the effects of varying humidities. Using actual data sets, the amount of icing forecast by the equation was more accurate at 50 percent than at 100 percent. Using Figure 20 of LTR-LT-98, Stallabrass concluded that the rate of accumulation can change by as much as 2.7 in/day (2.8 cm/hr) as the relative humidity varies between 20 percent and 100 percent.

Thus, we constructed a new nomogram that is better correlated to the Northeast Pacific (Fig. 4). This was done by changing the air temperature values of the ordinate by 4°F (2.2°C) as shown in the figure. This equated to an increased icing rate of about 1½ in per day in the upper

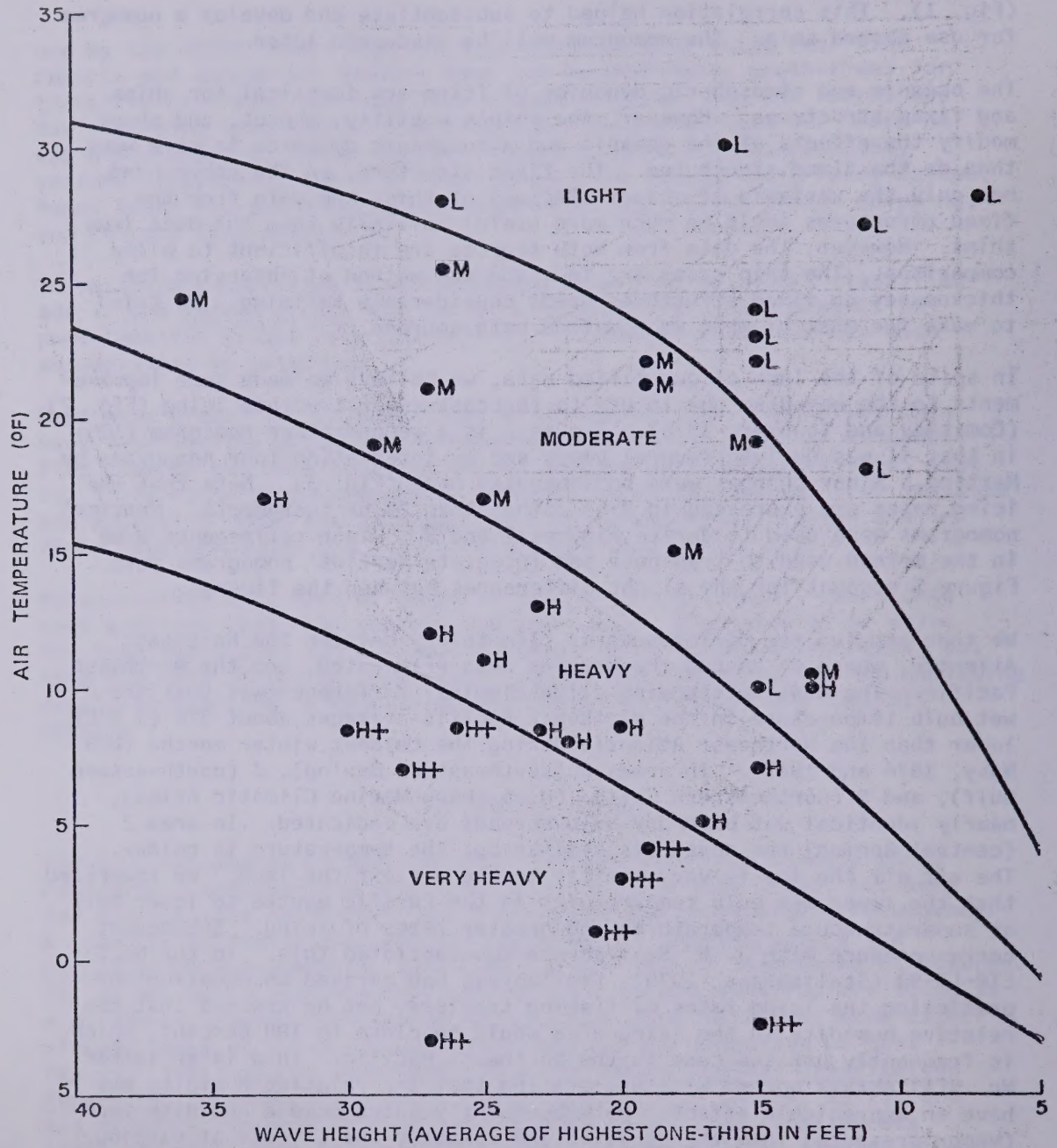
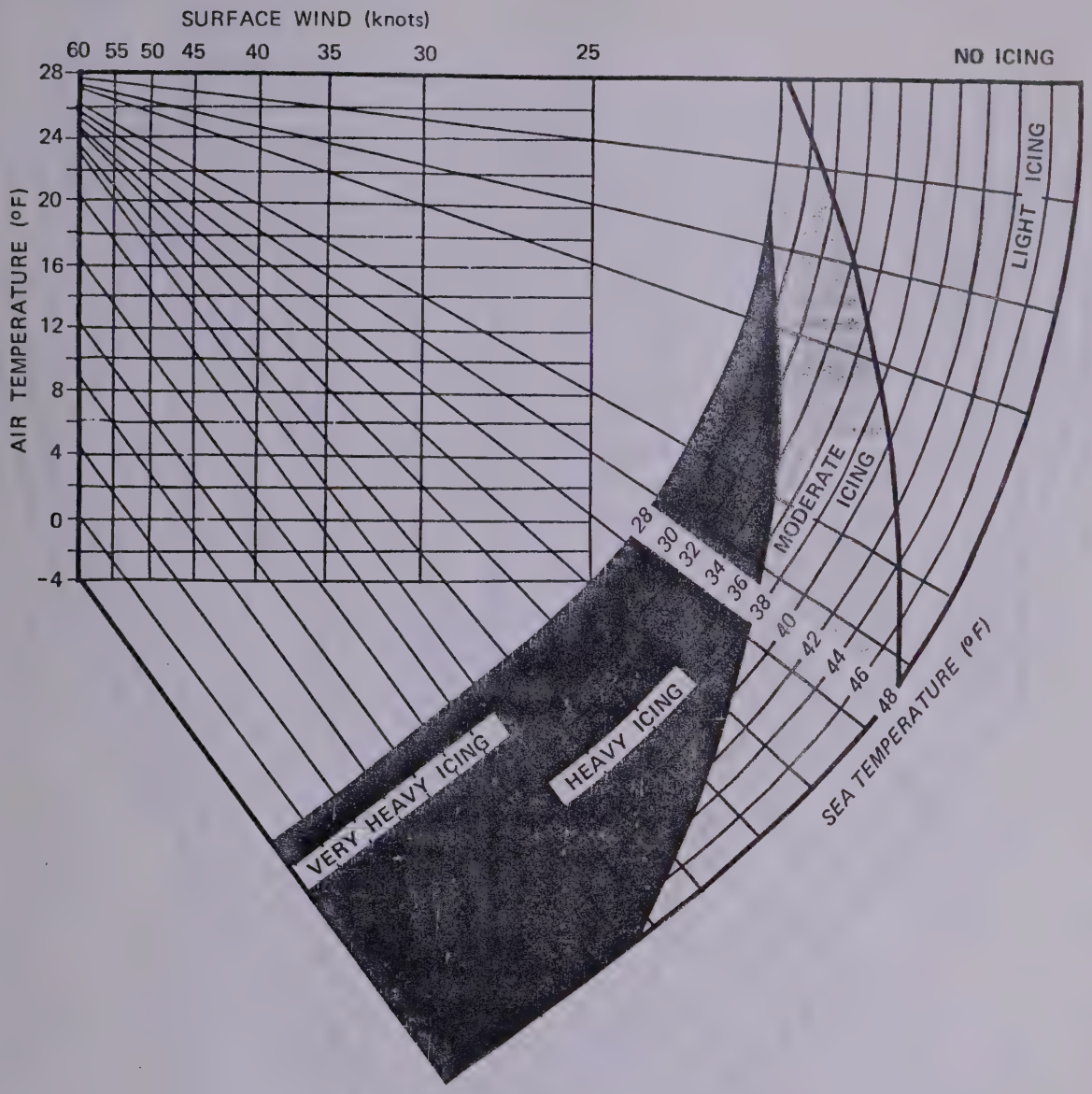


Figure 1. Scattergram of semi-quantified icing rate reports from the Ocean Bounty - winter of 1979-1980.

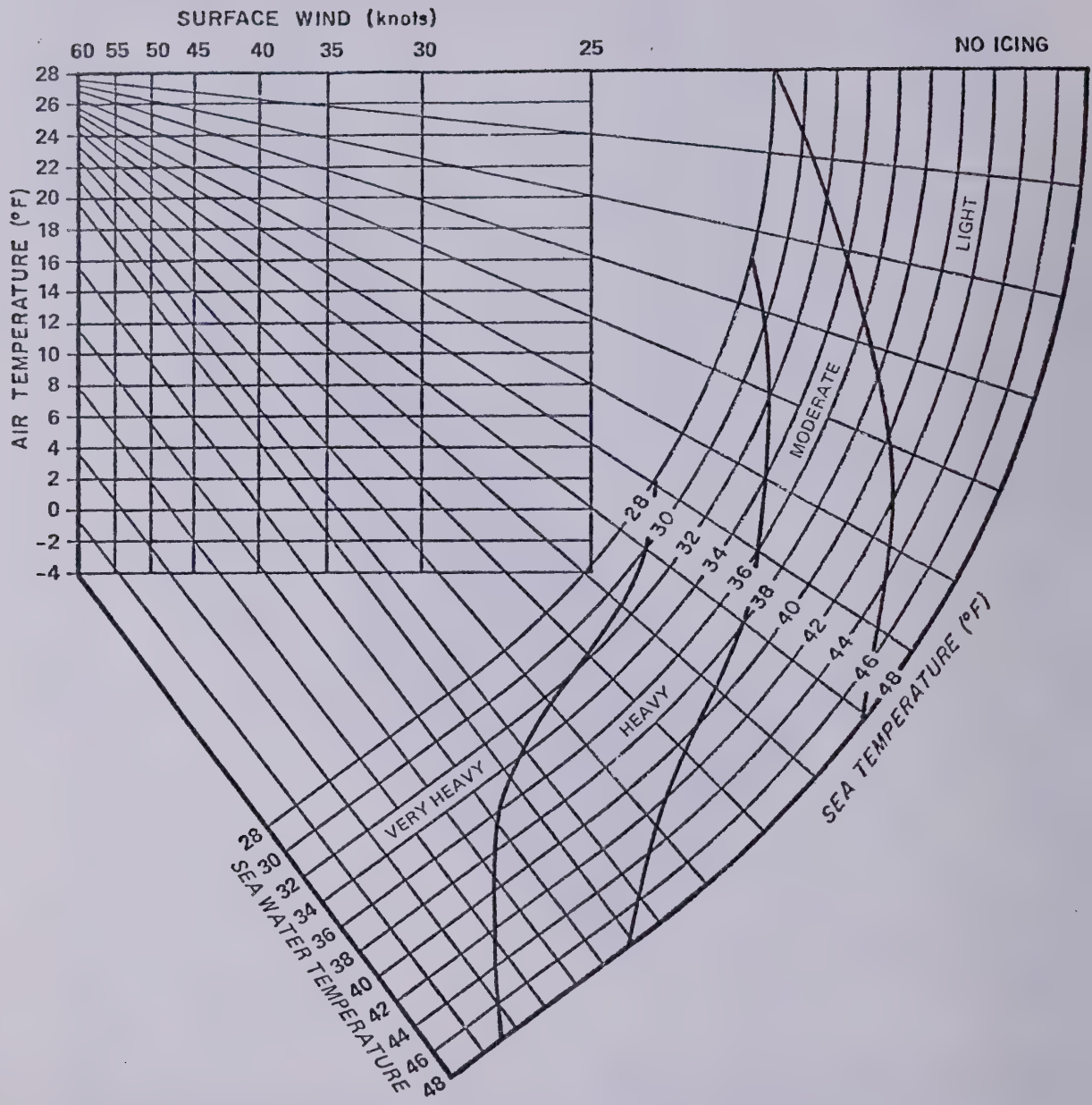


INSTRUCTIONS: Say that you estimate that the air temperature is 14°F, wind velocity is 30 knots, and the sea temperature is 32°F. Enter the nomograph on the 14°F line. Follow this line to the 30 knot wind velocity line. From the intersection of the two lines, follow the diagonal line to the appropriate water temperature line. At the intersection read off the icing category — in this case, heavy icing.

The icing categories used by the NWS are:

CATEGORY	ACCUMULATION
Light	0.4" to 1.4" in 24 hours
Moderate	1.4" to 2.6" in 24 hours
Heavy	2.6" to 5.7" in 24 hours
Very Heavy	5.7" + in 24 hours

Figure 2. A nomogram depicting the relationship between air temperature, surface wind, sea temperature, and icing categories (Comiskey and Younker, 1976).


SURFACE WIND (knots)
60 55 50 45 40 35 30 25
NO ICING
AIR TEMPERATURE (°F)
28 26 24 22 20 18 16 14 12 10 8 6 4 2 0 -2 -4
LIGHT
MODERATE
HEAVY
VERY HEAVY
28 30 32 34 36 38 40 42 44 46 48
SEA TEMPERATURE (°F)
28 30 32 34 36 38 40 42 44 46 48
SEA WATER TEMPERATURE

CATEGORIES

NAME	RATE PER 3 HOURS
Light	.05" to .2"
Moderate	.2" to .3"
Heavy	.3" to .75"
Very Heavy	.75+"

Figure 3. A "second-order nomogram" (SON) derived by integrating Mertins' nomogram (Mertins, 1968). The SON depicts the relationships between air temperature, surface wind, sea temperature, and icing categories.

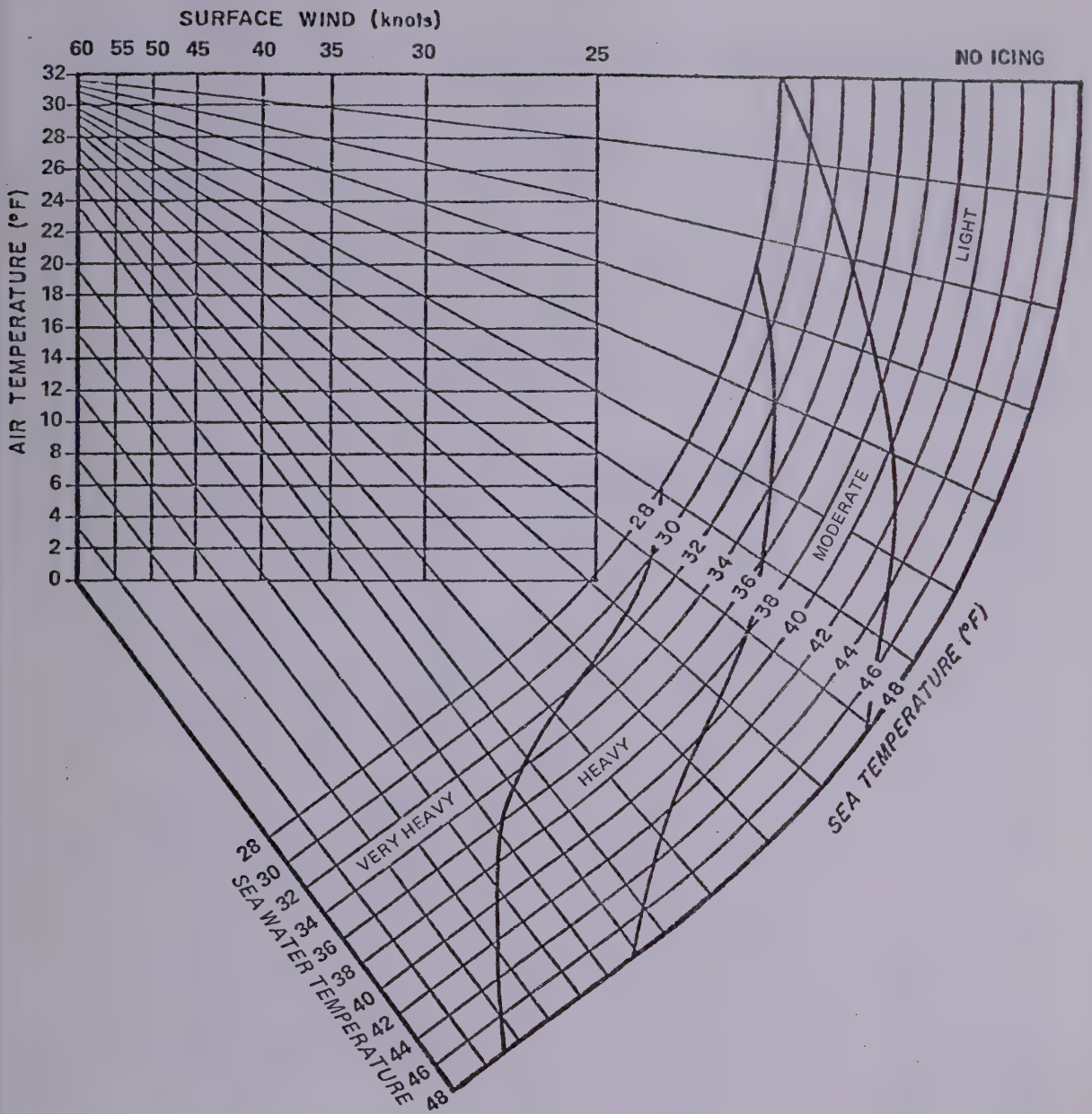

SURFACE WIND (knots)
60 55 50 45 40 35 30 25
NO ICING
AIR TEMPERATURE (°F)
32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
LIGHT
MODERATE
HEAVY
VERY HEAVY
28 30 32 34 36 38 40 42 44 46 48
SEA TEMPERATURE (°F)
28 30 32 34 36 38 40 42 44 46 48
SEA WATER TEMPERATURE

Figure 4. A second-order nomogram derived by integrating Mertins' nomograms (Mertins, 1968). The temperature scale (ordinate) has been relabeled (adjusted) to provide for differences in wet bulb climatology between the Northeast Atlantic and the Northeast Pacific. Categories same as Figure 1.

range of air temperatures, 20° to 34°F (-7 to +1°C), and about 1 in (2.5 cm) per day in the lower range 0° to 20°F (-18 to -7°C).

We changed the air temperature scale in Figure 5 another 2°F (1.1°C) to compensate for unusually low humidity conditions (RH 20 to 50 percent). This scale change equates to about 1/4 in of ice per day and, when combined with the first change of 4°F (2.2°C), should be an improved indicator of icing rates. We also looked at the temperature-dew point differences that would be required to equate to an RH of 50 percent. For the temperature ranges involved, 0° to 34°F (-18° to +1°C), the average difference required is 15°F (8.3°C), and it does not vary by more than 2°F (1.1°C) on either side of average. Consequently, we can state that whenever the temperature-dew point spread is greater than 15°F (8.3°C), the nomogram in Figure 5 should be used.

In addition to the changes in the upper-left portion of the original nomogram (Fig. 2), it seemed appropriate to modify the section of the nomogram that predicts icing rates (lower right). On the nomograms discussed thus far, the lines separating the rates were determined by the Mertins nomograms. In our opinion, these rates were too low and covered too long a time interval. Instead of 1.4 in (3.5 cm) in 24 hr, we used a rate of 0.25 in (.625 cm) in 3 hr, which equates to 2 in/day (5.0 cm/day); consequently we changed the boundaries of the icing rate areas to coincide with these new rates, as shown on Figure 6. The new rates are more easily estimated by shipboard personnel. To elaborate, the upper limit of Mertin's "light" category was 1.4 in/24 hr, or about 1/5 in per 3 hr. Our recommended upper limit is 2 in/24 hr or 1/4 in/3 hr. Our experience is that most mariners don't bother to report "light" icing, especially with an upper limit of 1/5 in/3 hr. The terminology (or icing rate adjectives) was unchanged except that another category was added: "extreme". We think there is a significant difference between 6 - 10 in/24 hr (very heavy) and 10+ in/24 hr (extreme). We had about five reported cases in the extreme range last winter. Figure 6 is recommended for use in the Northeast Pacific. Figure 7 is identical to Figure 6 except that we changed the temperature scale to handle unusually low humidity conditions; its primary use might be by professional forecasters who have an accurate measure of relative humidity. Many shipboard measurements are unreliable and should be used with caution. This is because of the incidence of coarse or fine spray on the dry bulb thermometer, which decreases the dry bulb/wet bulb spread.

Figure 8 is identical to Figure 6 except that the abscissa is a wind-wave index rather than just a wind scale. This is for use within 3 mi of a lee shore. Mariners frequently skirt the lee shore to avoid icing, so that they may encounter strong winds, but the waves will be relatively low. Since there appears to be a relatively good correlation between wave height and ice accumulation rates (Fig. 1), we invented the WIND-WAVE INDEX (wind in knots times wave height equals index). For example: if the wind is 50 kn (about 25 ms^{-1}) and waves are 3 ft (1 m), the index is 150. This nomogram is recommended for use aboard ship, where the wind speed is usually known with reasonable accuracy and where the wave height is known with considerable accuracy. The wind-wave index is based on empirical data to handle the strong wind-low wave situation. The wind X wave factor fits very nicely into the abscissa coordinate of

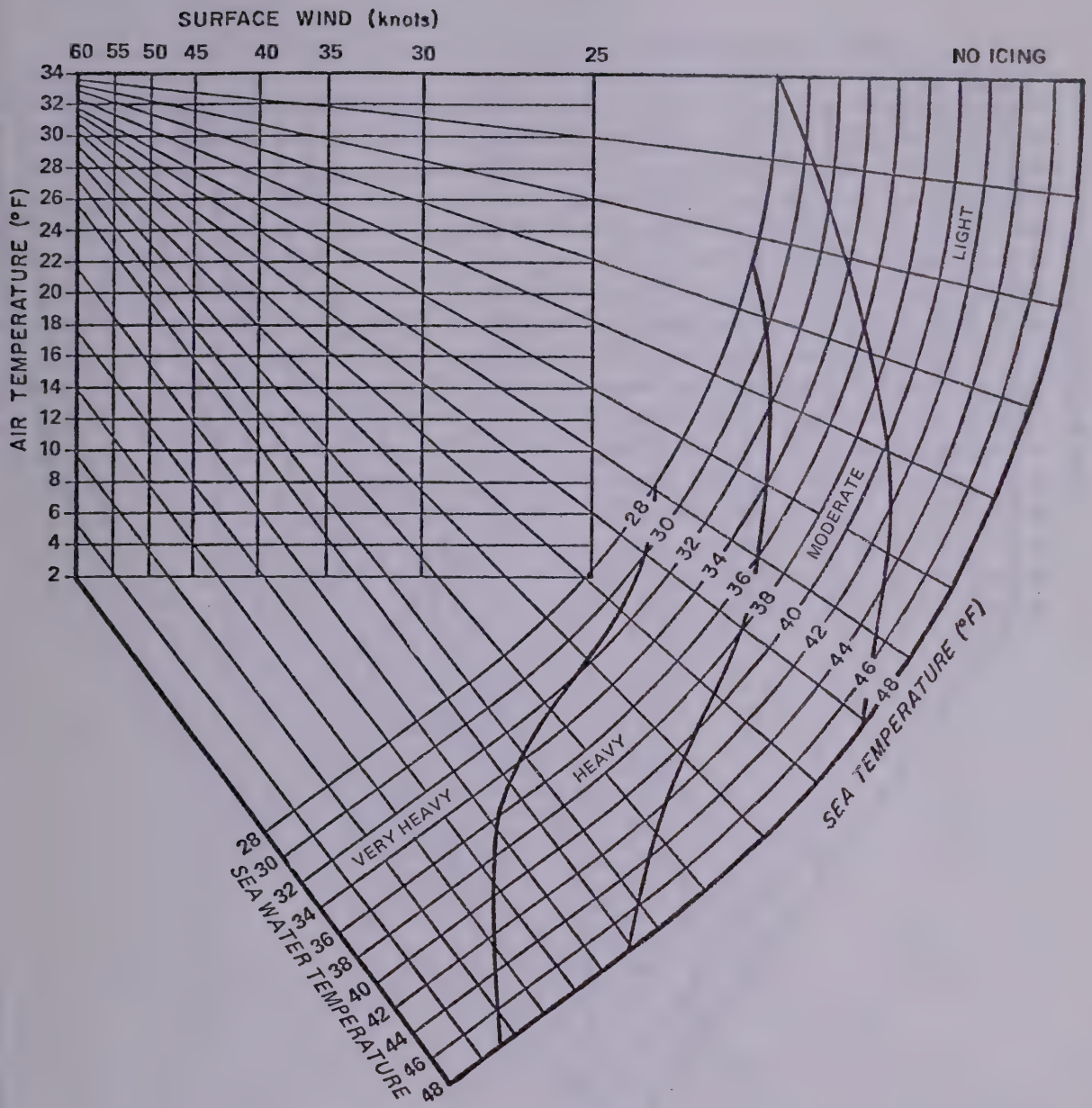
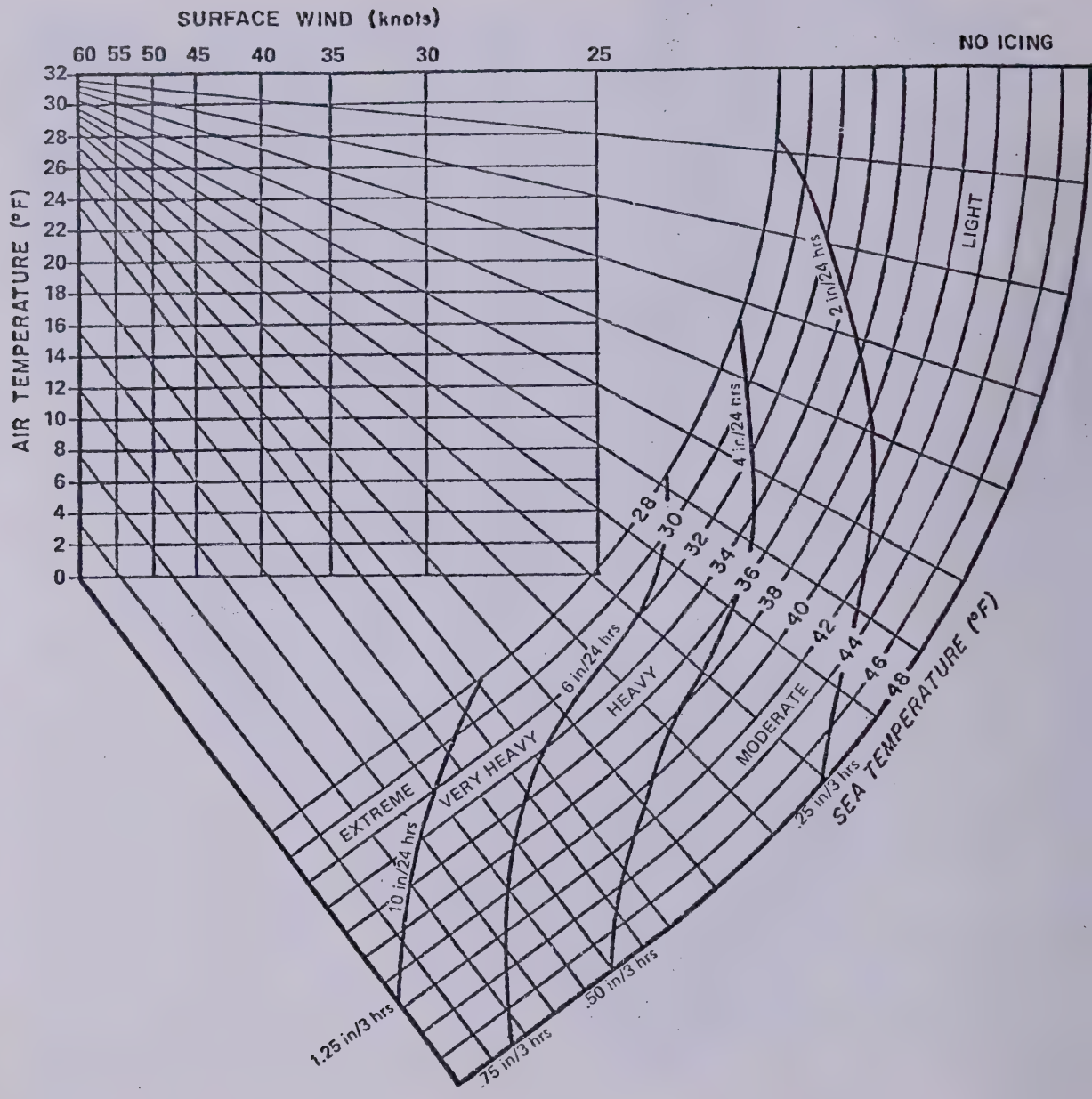
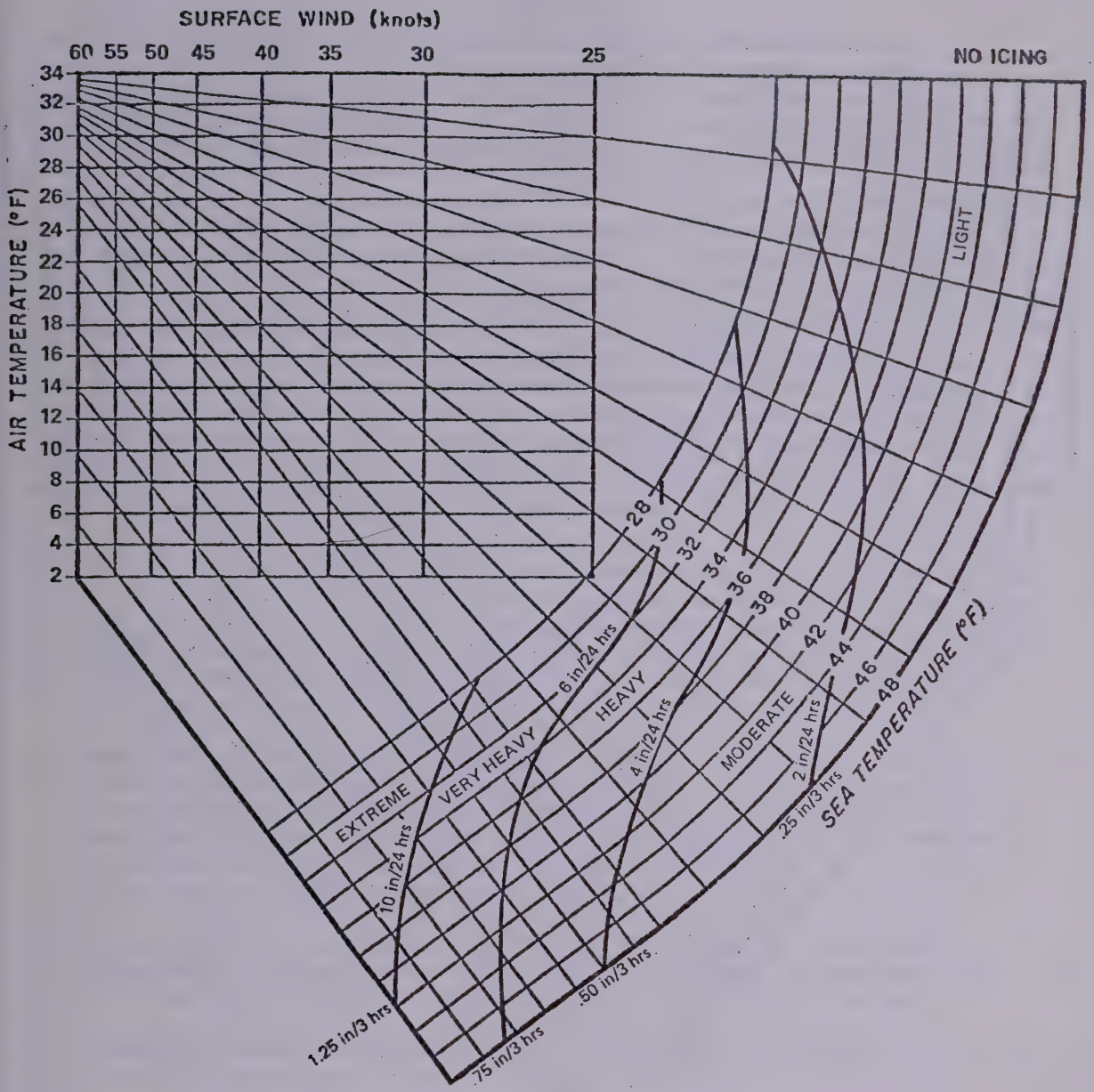

SURFACE WIND (knots)
60 55 50 45 40 35 30 25
NO ICING
AIR TEMPERATURE (°F)
34 32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2
LIGHT
MODERATE
HEAVY
VERY HEAVY
28 30 32 34 36 38 40 42 44 46 48
SEA TEMPERATURE (°F)
SEA WATER TEMPERATURE
28 30 32 34 36 38 40 42 44 46 48

Figure 5. A second-order nomogram derived by integrating Mertins' nomograms. The temperature scale (ordinate) has been relabeled (adjusted) to provide for differences in wet bulb climatology between the Northeast Atlantic and the Northeast Pacific and to provide for unusually low humidity (20%-50%) conditions (T-Td > 15°F). Categories same as Figure 1.



CATEGORIES	
NAME	RATE PER 3 HOURS
Light	.1" to .25"
Moderate	.25" to .50"
Heavy	.50" to .75"
Very Heavy	.75" to 1.25"
Extreme	1.25+"

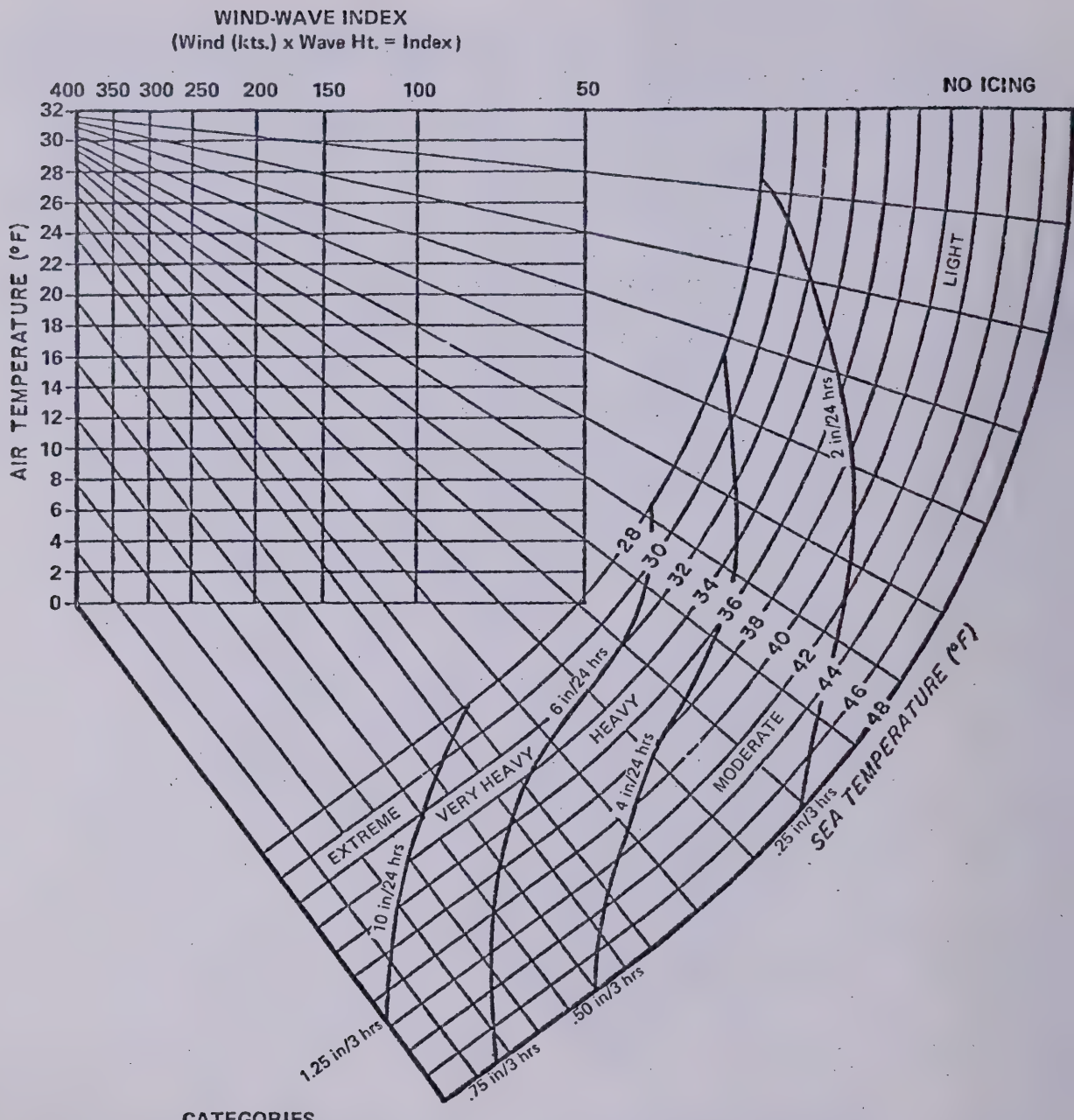
Figure 6. This figure is identical to Figure 2 except that the category boundaries are changed to be consistent with the new categories (left). Recommended for use in the Gulf of Alaska and eastern Bering Sea.



CATEGORIES

NAME	RATE PER 3 HOURS
Light	.1" to .25"
Moderate	.25" to .50"
Heavy	.50" to .75"
Very Heavy	.75" to 1.25"
Extreme	1.25+"

Figure 7. This figure is identical to Figure 6 except that the temperature scale has been relabeled to provide for unusually low humidity (20%-50%) conditions (T-Td > 15°F). Recommended for use in the Gulf of Alaska and by forecasters only.


WIND-WAVE INDEX
(Wind (kts.) x Wave Ht. = Index)
400 350 300 250 200 150 100 50
NO ICING
AIR TEMPERATURE (°F)
32 30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
LIGHT
2 in/24 hrs
28 30 32 34 36 38 40 42 44 46 48
SEA TEMPERATURE (°F)
MODERATE
.25 in/3 hrs
4 in/24 hrs
HEAVY
6 in/24 hrs
VERY HEAVY
.50 in/3 hrs
.75 in/3 hrs
EXTREME
10 in/24 hrs
1.25 in/3 hrs

CATEGORIES

NAME	RATE PER 3 HOURS
Light	.1" to .25"
Moderate	.25" to .50"
Heavy	.50" to .75"
Very Heavy	.75" to 1.25"
Extreme	1.25+"

Figure 8. Same as Figure 6 except that the wind scale (abscissa) has been replaced by a wind-wave index scale. This nomogram is recommended for use by mariners in the Gulf of Alaska and the eastern Bering Sea when within 3 miles of the lee shore. Example: wind = 50 kt; waves 3 ft.; index = 50 x 3 = 150.

the nomogram and the predictive results seem to be consistent with lee-side icing reports. The nomogram may need adjustment in the future, but is an obvious improvement, for lee-side conditions, over the unqualified temperature-wind nomogram. We feel that the nomogram should be "field" tested by mariners coincident with the accumulation of more data.

The areal distribution and frequency of icing can accurately be defined with a large number of nonquantified reports. Unfortunately, we have only 141. These reports are mostly from the last 4 years and are not considered to be representative. In fact, most are from the winter 1979-80. It was not possible to plot all the icing reports because the point density was too great in certain regions. Nevertheless, the area of occurrence of each report was represented within probable icing areas indicated by isolines and labeling. The icing areas enclosed by the isolines indicate areas where the most severe icing is likely to occur at any time (Fig. 9). The stationary "Ocean Bounty" made 38 icing reports during the winter of 1979-80.

6. CONCLUSIONS AND RECOMMENDATIONS

1. The data base is woefully inadequate. A long-term program of data acquisition should be implemented; 10 years may be adequate, 5 years would be a minimum. AEIDC now has the framework within which to acquire and store this type of data.

2. Well-documented quantified icing data are necessary to derive accurate correlations. Until these are available, the Mertins correlations, as adjusted to the Northeast Pacific, should be used. They are the best set of correlations known to AEIDC; however, there are problems with the Mertins nomograms that can not be completely resolved by tinkering with the temperature scale.

3. Figures 6 and 8 are superior to the present nomogram being used. They should be designed as a "stand-alone" handout to be distributed to organizations and individuals that operate in Alaska waters.

4. Figure 7 should also be designed as a "stand-alone" handout, but receive limited distribution.

5. The forecasting of superstructure icing can be automated, but before attempting this we recommend that NRCC LTR-LT-90 be studied carefully. In addition, any automated program for Alaska should include the effects of topography, as was done in our Figure 8. We believe that automated icing programs developed for land structures will not work on marine structures.

6. Because the entire marine community has responded to the project enthusiastically, AEIDC believes that the project is extremely worthwhile and urges PMEL to continue its efforts in this facet of atmospheric and oceanic science.

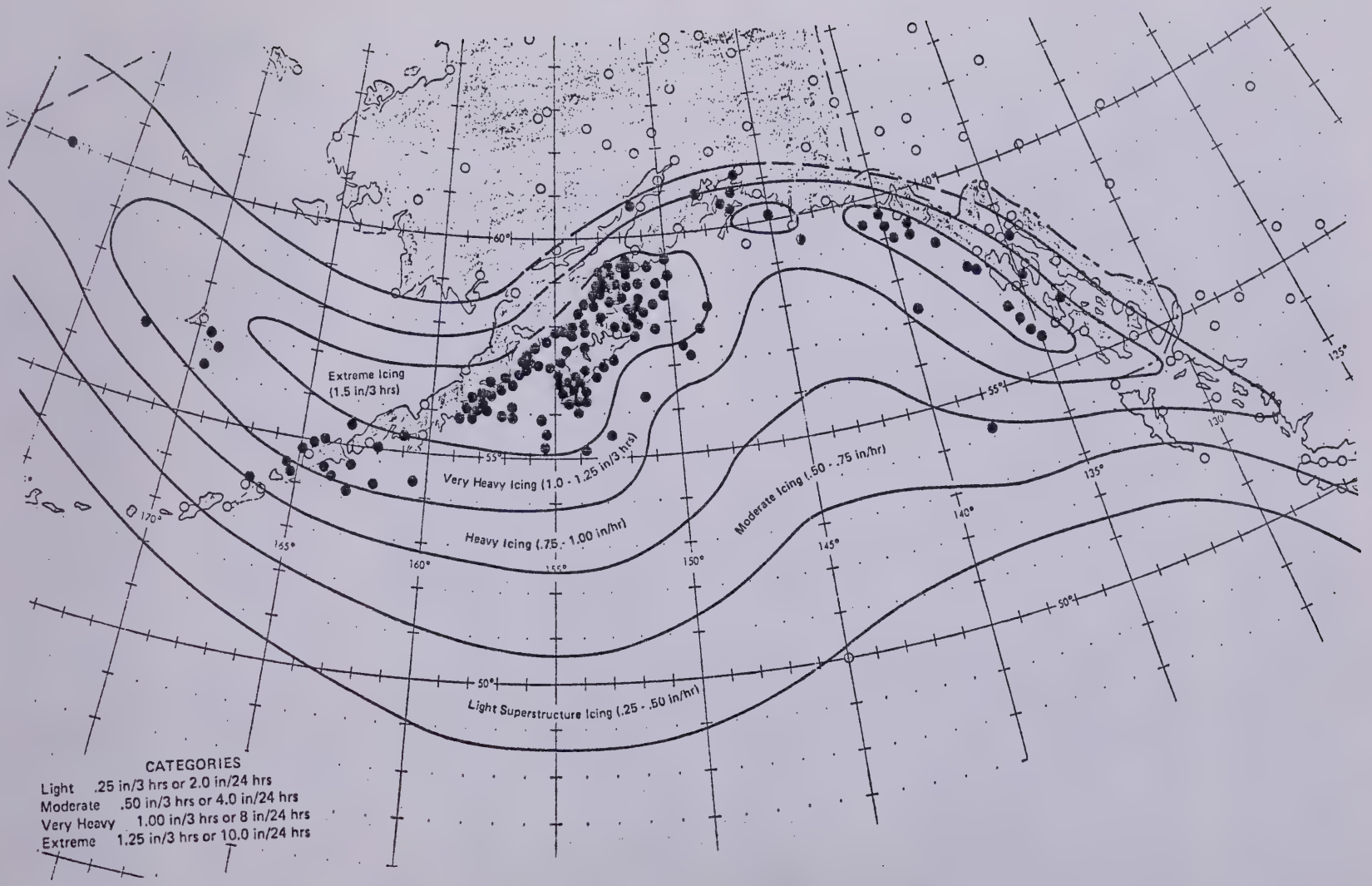

Extreme Icing
(1.5 in/3 hrs)
Very Heavy Icing (1.0 - 1.25 in/3 hrs)
Heavy Icing (.75 - 1.00 in/hr)
Moderate Icing (.50 - .75 in/hr)
Light Superstructure Icing (.25 - .50 in/hr)
CATEGORIES
Light .25 in/3 hrs or 2.0 in/24 hrs
Moderate .50 in/3 hrs or 4.0 in/24 hrs
Very Heavy 1.00 in/3 hrs or 8 in/24 hrs
Extreme 1.25 in/3 hrs or 10.0 in/24 hrs

Figure 9. Isolines indicate estimated zones of icing categories with the most extreme conditions. Black dots indicate known locations of icing events from January 1976 through January 1980.

7. A primary contribution of this study seems to be the recognition that relative humidity is important, but the only substantial statistical support is that provided by the U. S. Navy Marine Climatic Atlas. The case history data accumulated last winter tends to support the premise that RH is a significant factor, but the data sets are too few to be conclusive. However, Stallabrass' (personal communication) introduction of less than 100% RH terms in his automated icing program strongly tends to support the validity of the affects of variable RH conditions.

In summary, we believe that the superstructure icing study should be viewed as a preliminary look at the problem to determine what might be done in the future. This brief look at the problem revealed that some immediate, rather obvious improvements could be made to the superstructure icing nomogram. We feel certain that further improvements can be made and that data can be compiled that will have long lasting use.

7. ACKNOWLEDGMENTS

Funding for this study was provided by the National Oceanic and Atmospheric Administration (NOAA) through the Pacific Marine Environmental Laboratory, Marine Meteorological Study Group.

We owe special thanks to Mr. J. R. Stallabrass of the National Research Council Canada, Division of Mechanical Engineering, who provided particularly valuable input, and Peggy Dyson, who furnished frequent real-time reports of icing episodes. Ocean Routes and Phillips Petroleum were very helpful in the stationary platform data acquisition phase. Other helpful organizations were the U.S. Coast Guard, the Alaska State Ferry System, and Puget Sound Tug and Barge. Finally our thanks for the excellent secretarial, technical, and graphic support provided by AEIDC staff members.

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Appendix 1

SUPERSTRUCTURE ICING REPORT FORMS

SUPERSTRUCTURE ICING REPORT
(from Ship's log and other documents)

DATE _____ CASE NO. _____

Ship's Name _____ Type* _____

Length _____ Draft _____

Log No. _____ Time Span (of log) _____

Document _____ _____
Title Issue

Researcher: _____
Initials

ICING: Icing began _____
Day and Time

ended _____. Was continuous___/intermittent ____.
Day and Time

Icing was: Light _____ (a rate of .4" to 1.4" in 24 hours)
Moderate ___ (a rate of 1.4" to 2.6" in 24 hours)
Heavy _____ (a rate of 2.6" to 5.7" in 24 hours)
Very Heavy__ (a rate of 5.7"+ in 24 hours).

Total maximum accumulation during icing event was _____ inches.
Maximum rate (per/hour) of accumulation was _____ inches at approximately _____.
time

Evasive action** was taken YES _____ NO ____.

Icing ended due primarily to: 1. evasive action _____.
2. change in weather _____.
3. reaching destination _____.

General area of occurrence was from _____
geographical area (or lat. & long.)

to _____ with maximum rate of
geographical area

accumulation near _____.
geographical area

* Such as trawler, fishing boat, ferry, C.G. cutter, etc.

** Evasive action includes changes in course, speed, moving offshore, moving nearshore, entering sheltered areas, etc.

-over-

SHIP MOVEMENT:

Ship's Course: Ships general heading was _____***.

Ship's Speed: Average ship's speed was _____knots.

WEATHER:

1. Wind. The average wind speed and direction throughout the area was _____. The wind in the area of maximum accumulation (rate) was _____.

2. Temperature. The average temperature was _____.

SEAS: The average sea conditions were _____.

The seas in the area of maximum accumulation were _____.

REMARKS: _____

_____

_____

_____

_____

_____
Signature (and Title if applicable)

*** If in degrees, indicate whether true or magnetic. If variable, write in "variable". If not underway, write in "stopped," "working pots," or whatever describes the activity.

Form for Face-to-face or Telephone Interviews

SUPERSTRUCTURE ICING REPORT

DATE _____ CASE NO. _____

Interview with: _____
Name and Title if applicable.

Address: _____

_____

_____

Interviewer: _____
initials

Ship's Name _____ Type _____*

Length _____ Draft _____

ICING: Icing began _____
Day and Time

ended _____. Was continuous___/intermittent ____.
Day and Time

Icing was: Light _____ (a rate of .4" to 1.4" in 24 hours)
Moderate ___ (a rate of 1.4" to 2.6" in 24 hours)
Heavy _____ (a rate of 2.6" to 5.7" in 24 hours)
Very Heavy__ (a rate of 5.7"+ in 24 hours).

Total maximum accumulation during icing event was _____ inches.
Maximum rate (per/hour) of accumulation was _____ inches at approximately _____.
time

Evasive action** was taken YES _____ NO ____.

Icing ended due primarily to: 1. evasive action _____.
2. change in weather _____.
3. reaching destination _____.

General area of occurrence was from _____
geographical area (or lat.& long.)

to _____ with maximum rate of
geographical area

accumulation near _____.
geographical area

* Such as trawler, fishing boat, ferry, C.G. cutter, etc.

** Evasive action includes changes in course, speed, moving offshore, moving nearshore, entering sheltered areas, etc.

-over-

SHIP MOVEMENT:

Ship's Course: Ship's general heading was _____***.

Ship's Speed: Average ship's speed was _____knots.

WEATHER:

1. Wind. The average wind speed and direction throughout the area was _____. The wind in the area of maximum accumulation (rate) was _____.

2. Temperature. The average temperature was _____.

SEAS: The average sea conditions were _____.

The seas in the area of maximum accumulation were _____.

REMARKS: _____

_____

_____

_____

_____.

_____
Signature (and Title if applicable)

*** If in degrees, indicate whether true or magnetic. If variable, write in "variable". If not underway, write in "stopped," "working pots," or whatever describes the activity.

Form for Voluntary Reports from Marine Structures

SUPERSTRUCTURE ICING REPORT

DATE _____ CASE NO. _____

Arctic Environmental Information
and Data Center (AEIDC)
707 A Street
Anchorage, Alaska 99501

Dear AEIDC:

On _____ the _____
Date Name of ship, boat, or rig

experienced the following superstructure icing conditions: the icing was continuous ___/intermittent ___. It began at _____
time (LST,DST, or GMT)

and ended at _____.
time

ICING

Icing was: Light _____ (a rate of .4" to 1.4" in 24 hours)
Moderate ___ (a rate of 1.4" to 2.6" in 24 hours)
Heavy _____ (a rate of 2.6" to 5.7" in 24 hours)
Very Heavy__ (a rate of 5.7"+ in 24 hours).

Total maximum accumulation during icing event was _____ inches.
Maximum rate (per/hour) of accumulation was _____ inches at approximately _____.
time

Evasive action was taken* YES _____ NO ____.

Icing ended due primarily to: 1. evasive action _____.
2. change in weather _____.
3. reaching destination _____.

Location: Icing occurred generally from _____
geographical area (or lat. & long.)

to _____ with maximum rate of accumulation near
geographical area

_____.
geographical area

*Evasive action includes changes in course, speed, moving offshore, moving nearshore, entering sheltered areas, etc.

-over-

SHIP DATA

Ships Course: Ships general heading was _____**.

Ships Speed: Average ship's speed was _____knots.

Ship Length _____. Draft _____. Type***_____.

WEATHER:

1. Wind. The average wind speed and direction throughout the area was _____. The wind in the area of maximum accumulation (rate) was _____.

2. Temperature. The average temperature was _____.

SEAS: The average sea conditions were _____.

The seas in the area of maximum accumulation were _____.

REMARKS: _____

_____

_____

_____

_____.

_____
Signature (and Title if applicable)

** If in degrees, indicate whether true or magnetic. If variable, write in "variable". If not underway, write in "stopped," "working pots," or whatever describes the activity.

*** Such as trawler, fishing boat, C.G. Cutter, etc.

STATIONARY PLATFORM ICING REPORTS

Platform name _____ Location _____ Type*_____ Date _____

Hgt. of Anemometer_____ Hgt. of Observation Deck_____

Date (Day/Mo.)										
Times	began									
	of report									
	ended									
Rates	lgt. (.4-1.4)									
	mdt. (1.4-2.6)									
	hvy. (2.6-5.7)									
	hvy.+(5.7+)									
Max. Rate**										
Time of max. rate										
Max. ice thickness***										
Wind dir. & speed (kts)										
Sign. seas (H_s)										
Max. seas (H_m)										
Temps.	DB									
	DP									
	water									
Sky cond.										
Weather										
Visibility										
Obsvr init.										

* Semi-submersible, etc.
** Any hour
*** Any parts of structure not horizontal

Appendix 2

DESCRIPTIONS OF PROJECT USED TO PROMOTE COOPERATION

Advertisment in the "Kodiak Mirror"

"ATTENTION MARINERS"

Superstructure Icing Study in Progress

We have some information that is good news to the Alaska fishing industry or to any other activity that requires being on the ocean during the winter time. The Pacific Marine Environment Laboratory has hired the Arctic Environmental Information and Data Center (AEIDC) to collect Atmospheric and oceanic data that may correlate to Superstructure Icing aboard ships. The goal is to develop correlation that will make it less difficult to forecast the occurance and rate of Superstructure Icing. AEIDC hopes to develop graphic aids that can be used by ship-board personnel as well as professional forecasters.

The most important data to be collected will be air temperatures, wet bulb temperatures, sea surface water temperatures, and wind speed during known icing conditions. AEIDC will also collect data on ship speed, direction of travel, and ship size. If you experience significant icing conditions in the winter, please contact AEIDC at 279-4523 and ask for any of the following: Al Comisky, Jim Wise, Bill Wilson or Richard Becker. If any of these persons contact you, your cooperation will be very much appreciated. Please keep in mind that winter time fishing and other marine accidents have increased tremendously during the last four years. Coincidentally we have had 4 years of very mild winters. Let's not be lulled into a false sense of safety with respect to Superstructure Icing; next winter, or even the present winter, could be an icing humdinger.

Description of Project Included with Scientific Correspondence

Ship Superstructure Icing Study

The University of Alaska's Arctic Environmental Information and Data Center (AEIDC) is under contract to the National Oceanic and Atmospheric Administration to gather information to help the National Weather Service and others in the forecasting of superstructure icing in northern waters, particularly the Gulf of Alaska and the Bering Sea. AEIDC will gather case history data on occurrences of structural icing. The data will include date and time of the incident, location, severity, and rate of icing. In addition, we hope to gather data on direction, speed, and size of the affected vessels. Utilizing this icing information, AEIDC will then examine surface weather maps and other sources of information, to determine site- and time-specific values of wind speed and direction, sea state, air temperature, and dewpoint. We then hope to establish meaningful correlations between surface data and icing data to arrive at an improved objective method for forecasting vessel superstructure icing by trained operational forecasters and for shipboard personnel. The result of this project will be a report listing the data used, how and from whom it was obtained, analyses performed, and, hopefully, an improved nomogram for forecasting icing. The correlations and nomograms produced should be useful and equally applicable for all high-latitude (N of 50° N) oceanic areas where the dry or wet bulb temperature goes below freezing.

The National Weather Service, Alaska region, is now using a nomogram (see attached) that correlates air temperature, wind speed, and sea surface temperature to arrive at forecasts of superstructure icing of various intensities. Meteorological reasoning indicates that other parameters may also be indicators of structural icing. One such parameter is the wet bulb temperature. The temperature of a wet surface, i.e. the wet bulb temperature, is highly dependent on the relative humidity and dry bulb temperature. Even if the dry bulb temperature remains unchanged, lower relative humidities will produce lower wet bulb temperatures, and, therefore, colder surfaces (hulls and superstructures) to which ice may adhere. In addition, other parameters such as precipitation and/or fog, wind direction, and sea state also are important in affecting the rate of ice accumulation on vessel superstructures. Thus, AEIDC's study will correlate wet bulb temperature and other parameters to superstructure icing to help both civilian and government personnel in forecasting vessel superstructure icing rates in northern waters.

This project is the first of its type in Alaska. Completion of the final report is expected by the spring of 1980.

Superstructure Icing Study in Progress

We have some information that is good news to the Alaska fishing industry or to any marine activity that requires being on the ocean during the wintertime. The Pacific Marine Environment Lab (PMEL) has hired the Arctic Environmental Information and Data Center (AEIDC) to gather atmospheric and oceanic data that may correlate to superstructure icing aboard ships. The goal is to develop correlations that will make it less difficult to forecast the occurrence and rate of accumulation of superstructure icing. AEIDC hopes to develop graphic aids (nomograms) that can be used by shipboard personnel as well as professional forecasters.

The most important data to be gathered will be air (dry bulb) temperature, wet bulb temperature, sea surface water temperature, and wind speed during known icing conditions. AEIDC will also collect data on ship speed, direction of travel, and ship size. If you experience significant icing conditions this winter (79-80), please contact AEIDC at 279-4523 and ask for any of the following: Al Comiskey, Jim Wise, Bill Wilson, or Richard Becker or if any of these persons contact you, your cooperation will be very much appreciated. Please keep in mind that wintertime fishing activities and other marine activities have increased tremendously during the last four years. Coincidentally, we've had four years of very mild winters. Let's not be lulled into a false sense of safety with respect to superstructure icing. Next winter or even the present winter could be an icing humdinger.

☆GPO 1980—677-138/7

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WISE, J.L. and COMISKEY, A.L.
AUTHOR

Superstructure icing in Alaskan waters
TITLE

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